X-RAY AND GAMMA RADIATION PERSONAL DOSIMETERS
PM1621

Models:
PM1621
PM1621A
PM1621M
PM1621MA

OPERATING MANUAL

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This Operating Manual combined with the logbook and passport describes the design, operation and use of the X-ray and gamma radiation personal dosimeter:

- PM1621;
- PM1621A;

- PM1621M;
- PM1621MA

(further – dosimeter or instrument).

The Operating Manual includes the general description, specifications of the dosimeter, as well as some other information necessary for the proper operation of the dosimeter and a full realization of its possibilities.

During manufacturing of the dosimeter some changes may be introduced in its electrical scheme and construction that do not influence the specifications and metrological parameters and, therefore, may be not specified in this manual.

1 DESCRIPTION AND OPERATION OF THE DOSIMETER

1.1 Application Range

Dosimeter is designed for:

- continuous measurement of the personal dose equivalent (further – dose equivalent or DE) of external gamma and X-ray (further - photon) radiation $H_p(10)$;
- continuous measurement of the time of the DE accumulation;
- continuous measurement of the personal dose equivalent rate of external photon radiation $\dot{H}_p(10)$ (further – dose equivalent rate or DER);
- communications of information accumulated and stored in a non-volatile memory through infra-red (IR) communication channel (the protocol is compatible with IrDA interface) into the personal computer (PC) using the internal or external IR adapter.

Dosimeter is manufactured in four models:

- X-ray and gamma radiation personal dosimeter PM1621;
- X-ray and gamma radiation personal dosimeter PM1621A. Differs from PM1621 model by extended DER measurement range;
- X-ray and gamma radiation personal dosimeter PM1621M. Differs from PM1621 model by search mode and integrated vibro and light alarm;
- X-ray and gamma radiation personal dosimeter PM1621MA. Differs from PM1621 model by extended DER measurement range, search mode and integrated vibro and light alarm.

The dosimeters may be used independently or as a part of a system for everyday, efficient and emergency dosimetric control of the personnel and people at sites, production facilities and units, where there is a potential or real risk of exposure to external X-ray and gamma radiation by officers of customs and border services, personnel of nuclear facilities, radiological and isotope laboratories, officers of the emergency services, civil defense, fire brigades, police, as well as in other spheres of use where there is a necessity in measurement of the personal dose equivalent and personal dose equivalent rate, alarming of the exceeding of the preset dose and dose rate levels, information about the dose accumulation and conduct of the dose rate in time, as well as association of the measured parameters with an individual, systematization and complex analysis of the accumulated dosimetric information.

Operating conditions:

- ambient air temperature from - 40 up to 60 °C;
- relative humidity up to 98% at the temperature 35 °C;
- pressure from 84 up to 106,7 kPa.

A t t e n t i o n ! LCD will still continue to indicate the readings when the instrument is heated up + 50 °C.

1.2 Delivery kit

1.2.1 Delivery kit of the dosimeter corresponds to the Table 1.1.

Table 1.1

Item, type	Quantity, pcs			
	PM1621	PM1621A	PM1621M	PM1621MA
X-ray and gamma radiation dosimeter PM1621	1	-	-	-
X-ray and gamma radiation dosimeter PM1621A	-	1	-	-
X-ray and gamma radiation dosimeter PM1621M	-	-	1	-
X-ray and gamma radiation dosimeter PM1621MA	-	-	-	1
Accessories set:				
- IR channel adapter [1)]	1	1	1	1
- Power supply element PANASONIC POWER LINE LR6 AA [2; 5)] or Power supply element Energizer L91BP-2 AA [3; 5)]	1	1	1	1
-software	1 CD	1 CD	1 CD	1 CD
Operating manual [4)]	1	1	1	1
Cover [5)]	1	1	1	1
Packaging	1	1	1	1

[1)] Supplied by customer request, by separate order;
[2)] Used within the temperature range of minus 20 – plus 60°C. Usage of other batteries with similar parameters is allowed;
[3)] Used within the temperature range of minus 20 – plus 60°C. Usage of other batteries with similar parameters is allowed;
[4)] Methods of calibration are included;
[5)] Supplied on agreement with a customer (buyer).

1.3 Specifications

1	Operating mode:	- measurement of photon radiation DER; - measurement of photon radiation DE; - indication of settings; - search (for PM1621M, PM1621MA); - indication of partial and critical battery discharge; - audio and (additionally for PM1621M, PM1621MA) light and vibro alarm activation when DE or DER thresholds are exceeded - indication of the dosimeter's number ("blind dosimeter"); - PC data exchange
2	DER measurement range	
	- for PM1621, PM1621M	0.1 μSv/h – 100 mSv/h
	- for PM1621A, PM1621MA	0.1 μSv/h – 1.00 Sv/h
	DER indication sub-ranges	0,01 – 9,99 μSv/h; 10,0 – 99,9 μSv/h; 100 – 999 μSv/h; 1,00 – 9,99 mSv/h; 10,0 – 99,9 mSv/h; 100 – 200 mSv/h (PM1621, PM1621M); 100 – 999 mSv/h (PM1621A, PM1621MA); 1,00 – 2,00 Sv/h (PM1621A, PM1621MA).
	- DER analogue scale (seven segments) in a logarithmic gauge	Number of indicated segments (from left to right) corresponds to the following DER threshold values on the LCD display: - one segment – ≥ 1.0 mSv/h; - two segments – ≥ 10 mSv/h; - three segments – ≥ 100 mSv/h; - four segments – ≥ 1.0 mSv/h; - five segments – ≥ 10 mSv/h; - six segments – ≥ 100 mSv/h (PM1621, PM1621M); - seven segments – ≥ 1.0 Sv/h (PM1621A, PM1621MA)
3	Maximum permissible intrinsic relative error of DER measurement	$\pm(15 + K_1/\dot{H} + K_2 \dot{H})$ %, where $\dot{H}$ – DER value, mSv/h; K_1 – coefficient 0.0015 mSv/h; K_2 – coefficient 0.01 $(mSv/h)^{-1}$
4	DE measurement range	1.0 μSv – 9.99 Sv
5	Maximum permissible intrinsic relative error of DE measurement	± 15 %
6	DE indication range	0.01 μSv – 9.99 Sv
	Indication sub-ranges:	0.01 – 9.99 μSv; 10.0 – 99.9 μSv; 100 – 999 μSv; 1.00 – 9.99 mSv; 10.0 – 99.9 mSv; 100 – 999 mSv; 1.0 Sv – 9.99 Sv
7	Discreteness of DE accumulation time indication	1 h

8 The dosimeter provides inputting, storage in a non-volatile memory and continuous control of two DER and DE threshold levels within the whole measurement range, various audible alarms, as well as vibro and light alarms (additionally for PM1621M, PM1621MA) at exceeding of the preset first and second threshold levels.

Discreteness of threshold level setting — Unit of lower-order indicated position

9 Registered energy range — 10 keV – 20 MeV

Energy response relative to 0.662 MeV (^{137}Cs), no more than — ± 30%

10 Coefficient of variation (deviation of the dosimeter's readings caused by statistic fluctuations) at DER measurement at a confidence coefficient 0,95, no more than — ± 10%

11 Anisotropy (type dependence is given in Attachment A) of the Dosimeter for each energy does not exceed values (in %) presented in Table 1.2, when the Dosimeter is rotated in the horizontal plane (Attachment B, figure B.1) and values (in %) presented in Table 1.3, when the Dosimeter is rotated in the vertical plane (Attachment B, figure B.2).

Table 1.2

Angle of detection relative to the direction of graduation, °	Energy of gamma radiation, MeV		
	Anisotropy		
	0.059	0.662	1.25
0	0	0	0
15	± 5	± 5	± 5
30	± 10	± 10	± 10
45	± 20	± 15	± 15
60	± 40	± 20	± 20
-15	± 5	± 5	± 5
-30	± 10	± 10	± 10
-45	± 20	± 15	± 15
-60	± 40	± 20	± 20

Table 1.3

Angle of detection relative to the direction of graduation, °	Energy of gamma radiation, MeV		
	Anisotropy		
	0.059	0.662	1.25
0	0	0	0
15	± 5	± 5	± 5
30	± 10	± 10	± 10
45	± 20	± 15	± 15
60	± 40	± 20	± 20
-15	± 5	± 5	± 5
-30	± 10	± 10	± 10
-45	± 20	± 15	± 15
-60	± 40	± 20	± 20

12 Maximum permissible additional relative error of DER measurement:

- at temperature variations from minus 40 to plus 60 °C — ± 10%
- at relative humidity of ambient air 98 % at 35 °C — ± 10%
- at power voltage variations from nominal value to limiting voltage values — ± 5%

	- on exposure to magnetic field of 400 A/m strength	± 5%
	- on exposure to radio frequency electromagnetic fields of 30 V/m strength	± 5%
13	LCD backlight at pressing LIGHT/SET button	3-5 s
14	Instability of readings during 24 hour continuous work, no more than	5%
15	Response time when DER value is increased more than 10 times, from initial low DER value to finite fixed high DER value exceeding 10 μSv/h, no more than	5 s
16	Response time when DER value is decreased more than 10 times, from initial high to finite fixed low DER value exceeding 10 μSv/h, no more than	10 s
17	PC communication	- by a special program using IR communication channel adapter
18	In the mode of data transmission to PC the dosimeter provides the following functions:	1) permission or prohibition the following be displayed on LCD: - DER or DE photon radiation measured value indication; - relative mean square error of average value of measurement result with 0.95 probability (statistical error) in percents; - dosimeter number (“blind dosimeter”); 2) reading from PC into dosimeter and storing in instrument’s non-volatile memory the following information: - dosimeter serial number; - history of DE and DER accumulation at user set time periods; - DE (DER) values when set thresholds are exceeded, as well as time, date and month, when set thresholds where exceeded; - DE and DER set thresholds values; - service information; 3) following information is recorded from PC to dosimeter: - values of DE and DER thresholds being set; - current date and time for DE accumulation history; - operation modes.
19	In the search mode the dosimeter PM1621M, PM1621MA) enables following functions:	- detect and locate the photon radiation sources on the basis of audio-, vibro- and light (LED blinking) alarm signal frequency changes; - search mode on/off; - search mode on/off state indication.

20	Sound pressure level at the distance of 20 cm (for PM1621M, PM1621MA), no less	85 dB (A).
21	Power supply	1.5 (+ 0.1; minus 0.4) V (one AA type battery)
22	Period of continuous operation of the dosimeter from one battery, using LCD backlight not more than 20 s/day, audible alarm – not more than 20 s/day and at an average value of the measured DER up to 0.3 μSv/h:	
	- at a temperature from 0 up to 60°C	12 months
	- at a temperature minus 40°C, at least:	6 months
23	Protection degree of the dosimeter's case	IP67
24	The dosimeter is proof against the action of:	- temperature of an ambient air from minus 20 up to plus 60 °C with indication of measurement results on LCD; - temperature of an ambient air from minus 40 up to minus 20°C without indication of measurement results on LCD but with recording of measurement results in a non-volatile memory; - relative humidity of an ambient air up to 98 % at 35 °C; - atmosphere pressure from 84 up to 106,7 kPa
25	The dosimeter is proof against:	- sinusoidal vibration in the frequency range 5 - 35 Hz and bias amplitude for frequencies lower than the transition frequency 0.75 mm; - shocks with acceleration 100 m/s^2, duration of shock pulse 2-50 ms, shock rate is 60 - 180 shocks per minute
26	The dosimeter meets drop test against a concrete surface from the height	0,7 m
27	The dosimeter is proof against the action of static and variable magnetic fields of strength	up to 400 A/m
28	The dosimeter is proof against the action of radio frequency electromagnetic fields up to 30 V/m in the frequency range from 80 to 1000 MHz, from 800 to 960 MHz, from 1.4 to 2.5 HHz of strength (in electromagnetic emission envoronment of digital radiophone) - the dosimeter is proof against the action of electrostatic discharges, test level 3 (air discharge, 8 kV, contact discharge 6 kV) , performance criterion B; - dosimeter corresponds electromagnetic compatibility state standard of manufacturing country (EN 55022:1998 (class B)) requirements by the level of emitted radio noise	
29	The dosimeter in a transport package is proof against the action of:	- temperature from minus 50 up to plus 50 °C; - humidity up to 100 % at 40 °C; - shocks with acceleration 98 m/s^2, duration 16 ms; - vibrations with frequency 5-35 Hz and bias amplitude 0.75 mm

30	Weight, no more	
	- PM1621, PM1621A	0.165 kg
	- PM1621M, PM1621MA	0,185 kg
	Weight in package	not more than 0.4 kg
31	Overall dimensions, no more	not more than 87x72x39 mm
32	Reliability parameters:	
	- average full operating time	no less than 20000 h;
	- average service life	no less than 10 years
	- average time of recovery	no more than 60 min

Note – For addition information about dosimeter, please visit **www.polimaster.com**.

1.4 Design and theory of operation

1.4.1 The dosimeter comprises the following main blocks and modules:
- radiation detector;
- microprocessor;
- LCD;
- secondary power supply;
- IR-transceiver;
- non-volatile memory.

The block diagram of the dosimeter is shown in Figure 1.1.

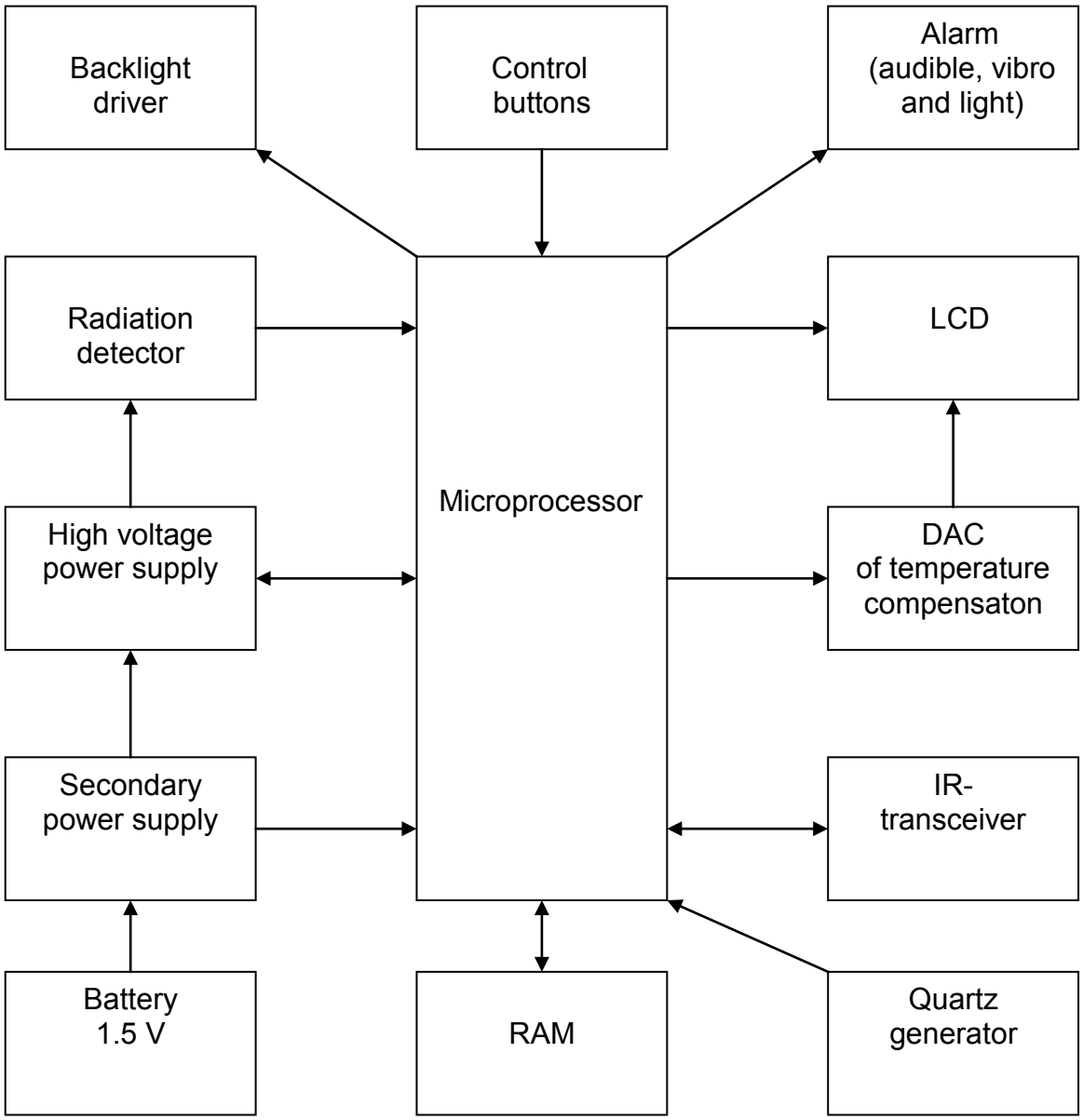

Figure 1.1 – Block diagram of the dosimeter

A Geiger-Muller tube with a filter for spatial-energy formation of sensitivity, which converts photon radiation quanta to electric pulses, is used as a radiation detector. The detector has a high-voltage power supply.

The microprocessor controls the dosimeter's operating modes, backlight driver, audible alarm driver, infrared communication channel, LCD, non-volatile memory, high-voltage power supply of the detector, operates the control buttons, performs all the necessary calculations, self-diagnostics.

The dosimeter's operating algorithm ensures continuity of the measurement process, statistical processing of the measurement results, a prompt adaptation to the variation of level of the photon radiation dose rate (setting the time of measurement in inverse dependence on the dose rate) and effective output of the information obtained to the LCD. The IR-communication channel provides an exchange of information with PC.

The dosimeter has an internal non-volatile memory that allows the information accumulation and storage.

Secondary power supply provides transformation of the battery's voltage 1.5 V into a stable voltage 3.0 V necessary for the dosimeter's power supply.

1.4.2 The Dosimeter is designed as a unit housed in a plastic shock-proof case. General overview of the dosimeter and its parts are shown in Figure 1.2. Indication elements, positions **1** – **4**, are on the LCD (**8**).

1 – DER analog scale (seven segments) for effective control over radiation situation, analog scale (four segments) – sound pressure level indicator in the search mode;

2 – DER digital panel in DER measurement mode, DE in DE measurement mode, year of production in the dosimeter's number indication mode, indication of IR communication channel switch on/off in the PC communication mode;

3 – digital panel of indication of statistical error in percents in DER measurement mode, DE accumulation time indication in thousands of hours (h) in DE measurement mode, month of production in the dosimeter's number indication mode;

4 – digital panel of indication of time of averaging DER values (in seconds) in DER measurement mode, of DE accumulation time in DE measurement mode;

5 – the ✳ (**LIGHT/SET**) button for switching on LCD backlight, switching on PC communication mode, entering the set mode and exiting it;

6 – the ⭘ (**MODE**) button for selecting the dosimeter's indication mode (DER, DE, the dosimeter's number, PC communication);

7 – light alarm outlet;

8 – LCD;

9 – IR-transceiver window;

10 – detector;

11 – screw-cover of battery compartment.

A direction of calibration and the detector effective center relative to which the factory calibration is performed are placed at a 15 mm distance from the dosimeter detector's surface (Attachment C).

The total surface density of the walls surrounding the detector is 1 g/cm^2 that provides the detector shielding from the background beta radiation.

PM1621M and PM1621MA dosimeters are equipped with removable clip to be worn on belt. See Figure 1.3 for the way to demount the clip from the dosimeter body.

Dosimeter can be supplied with protective case made from synthetic fabric so that user can wear it on the belt. Polimaster recommends demounting the clip when wearing dosimeter in protection cover.

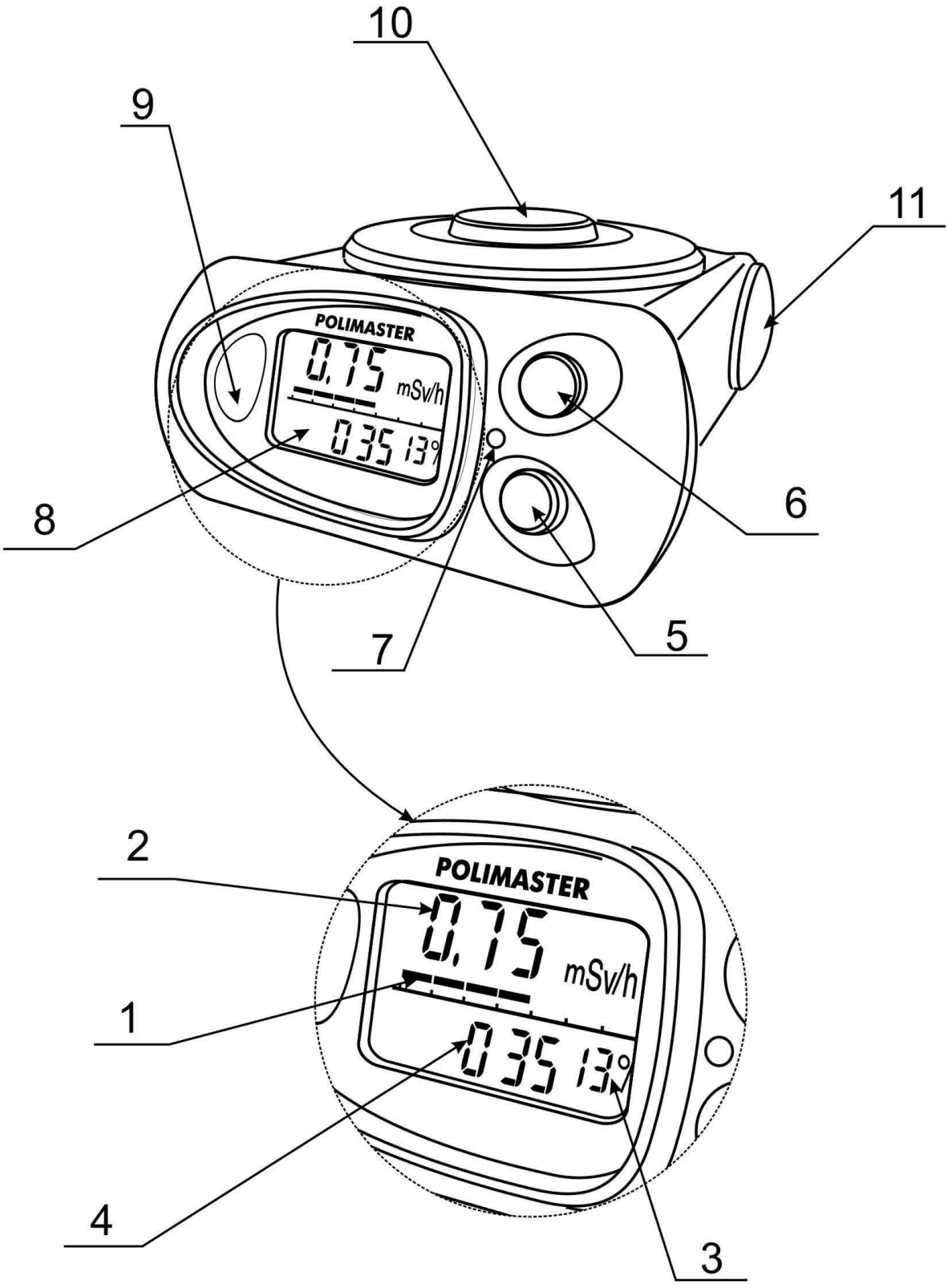

Figure 1.2 – General overview of the dosimeter

Figure 1.3 – Demounting the clip from PM1621M and PM1621MA

2 USE OF THE DOSIMETER

2.1 General guidelines

When purchasing the dosimeter it is necessary to check the delivery kit (chapter 1.2.1) and the proper operation of the instrument in all the operation modes (chapter 2.4).

Protect the instrument from shocks and mechanical damages. Avoid exposing the dosimeter to hostile environments, organic solvents and open fire.

2.2 Safety instructions

During the dosimeter adjustment, checking, repair, maintenance and verification, if the radioactive sources are used, the regulations for work with radioactive materials and other radiation sources, as well as Standards of radiation safety should be followed.

2.3 Preparation for use

2.3.1 It is necessary to study all sections of the present operating manual before using the dosimeter.

2.3.2 Unpack the dosimeter.

2.3.3 Switching on:

- unscrew the battery compartment's cover using the screwdriver;
- insert the battery, observing the polarity (battery's electrode marked with "+" should be directed inside the dosimeter);
- fix the battery compartment's cover in its place.

Right after inserting the battery the dosimeter performs LCD testing (all the segments and graphic symbols should be displayed for about 2 s and then disappear), then the dosimeter should enter the measurement mode. One minute after inserting the battery the dosimeter is ready for use.

2.3.4 Place and fix the dosimeter, detector outwards, on a breast pocket of overalls or inside it.

Attention! If the dosimeter is expected to be used under conditions when the dose rate value is higher than 0.1 mSv/h, it is recommended to insert a new battery.

2.4 Use of the dosimeter

2.4.1 Dosimeter operation modes

- photon radiation DER measurement mode;
- photon radiation DE measurement mode;
- dosimeter's number indication mode ("blind dosimeter");
- mode of data transmission to PC;
- search mode (for PM1621M and PM1621MA);
- mode of audio alarm state indication;
- mode of vibro alarm state indication (for PM1621M, PM1621MA)
- partial or critical battery discharge indication mode;
- settings mode;
- audible alarm mode at the exceeding of the preset DE or DER thresholds, as well as vibro and light alarm mode for PM1621M and PM1621MA additionally.

The dosimeter's non-volatile memory ensures storage of the following values when replacing the battery for the moment of the battery's removal:

- accumulated dose (DE);
- DE accumulation time;
- DE and DER accumulation history;
- preset DER and DE thresholds values.

When using the dosimeter in a temperature range from -40 up to -20°C the Dosimeter provides performance of the dosimetric functions without displaying the result of measurement on LCD. When returning the dosimeter into conditions with a temperature higher than -20 °C LCD operates in a normal way.

The dosimeter performs continuous DER and DE measurement, DE accumulation time counting in all modes, excluding an active mode of data transmission to PC (Ir/on).

Standard configuration of the dosimeter when shipping ensures indication of the following parameters and functions performed:

DER measurement mode – On
On a display (2), figure 1.2 – DER values output
On a display (3) – output of statistical error values, % - Off
On a display (4) – output of DER values averaging - Off
Thresholds setting enable - On
Audible alarm - On

DE measurement mode – On
On a display (2), figure 1.2 – DE values output
On a display (3) – output of DE accumulation time values in thousands hours (symbol “h” is indicated at DE accumulation time less than a thousand hours).
On a display (4) – output of DE accumulation time values in hours - On
On a display (4) – output of the values of time remaining for staying at the working place - Off
Thresholds setting enable On
DE reset On
Audible alarm On

Dosimeter’s number indication mode – On
On a display (2), figure 1.2 - dosimeter’s number;
On a display (3) - month of the dosimeter’s production;
On a display (4) - year of the dosimeter’s production;
Audible alarm - On

Search mode - On.

Audio alarm indication mode - On.

Vibro alarm indication mode - On.

2.4.2 Selection of an indicated parameter

Modes of DER, DE, dosimeter’s number and data transmission to PC indication are switched on by a successive pressing of the MODE button (figure 2.1 and 2.2).

The dosimeter allows switching on/off all the above-mentioned indication or measurement modes. Change of the configuration is performed in the mode of data transmission to PC.

2.4.3 DER measurement mode

In the DER mode (figure 2.1 and 2.2) the following values are indicated on the LCD:
- DER (μSv/h, mSv/h, Sv/h);
- DER on the analogue scale in a logarithmic gauge (seven segments);
- statistical error in percents;
- averaging time of DER values (Range of the averaging time indication is from 1 up to 2999 s. If the averaging time exceeds 2999 s, the symbols “**- - -**” are indicated on the LCD).

If the measured DER value is over the upper limit of the DER indication range (200 mSv/h for the PM1621, PM1621M and 2.0 Sv/h for PM1621A, PM1621MA), the LCD will show the overload symbol "**OL**" and non continuous audible signal will sound.

In the DER mode the collected statistics of DER measurement can be reset and the process of measurement can be reactivated by simultaneous pressing of the **LIGHT/SET+MODE** buttons.

2.4.4 DE measurement mode

In the DE mode (figure 2.3) the following values are indicated on the LCD:

- DE (μSv, mSv, Sv);
- DE accumulation time.

DE and DE accumulation time reset is possible in the set mode by simultaneous pressing of the **LIGHT/SET+MODE** buttons (figure 2.3).

In the mode of data transmission to PC it is possible to set an inhibit for DE reset using the buttons.

There are two methods of measurement of the DE accumulated over a certain period of time.

The first method (recommended). In the beginning of measurement the DE should be reset using the keys or the PC and the user software supplied on CD. Then the dose displayed at the end of the period will be the dose accumulated over the period of measurement.

The second method. The dose value in the beginning of the period of measurement should be deducted from the DE value displayed at the end of the period.

In the DE mode the indication (figure 1.2 display (3) and (4)) of values of time remaining for staying at the working place depending on the current measured DER and DE values is possible. Calculation of time is performed relative to the second preset DE threshold (the function may be switched on at the DE measurement mode configuration).

2.4.5 Settings mode

Auxiliary mode of settings (figure 2.4) is meant for verification and (or) setting of the threshold DE (DER) values, DE and DE accumulation time reset.

Attention! To enter the "set" mode press and hold for about 5 s the LIGHT/SET button and the parameter to be set will be flashing.

To choose the parameter press and release the **LIGHT/SET** button.

To change the set parameter:

- rapidly – press and hold the **MODE** button;
- for exact setting – press and release the **MODE** button.

The dosimeter will exit the "set" mode by pressing and holding the **LIHGT/SET** button or automatically in approximately 90 s.

Inputting the DER (DE) threshold levels into the memory

This procedure can be performed in the DER (DE) measurement mode as well as in the mode of data transmission to PC. DER (DE) thresholds are inputted during DER (DE) measurement on the LCD.

Enter the settings mode by pressing and holding the **LIHGT/SET** button (figure 2.4).

Input successively the first and then the second threshold levels.

Exit the set mode.

In the mode of data transmission to PC it is possible to set an inhibit for changing the threshold levels using the buttons.

In case of exceeding the value of the first (second) DER (DE) threshold the dosimeter turns correspondingly into the DER (DE) measurement mode and noncontinuous (frequent noncontinuous) audible signal will sound.

When DER value decreases below the preset threshold, the audible signal will shut off. Press any button to silence the alarm sound. The audible signal will shut off

automatically in approximately 60 s, the repeated audible signal will sound in approximately 4 min.

2.4.6 The dosimeter's number indication mode

In the dosimeter's number indication mode the following items are indicated on the LCD:

- the dosimeter's number on a display (2);
- year (4) and month (3) of production.

2.4.7 Mode of data transmission to PC

2.4.7.1 The dosimeter allows storing and transmitting to PC a history (further – "history") of DE, DER accumulation, events of exceeding the preset DE and DER threshold values, event of DE reset trough IR communication channel using the buttons.

Selection of the events to be stored in the history, frequency of these recordings is performed under a special program. History data are inaccessible without IR adapter (internal or external).

The dosimeter performs data transmission to PC under the user software supplied on CD through the adapter of IR communication channel over the communications protocol compatible with IrDA interface.

System requirements to a computer:

- A PC not lower than Pentium III;
- 1 GB free HDD space;
- printer and unit for operation with IrDA protocol for the exchange of information with the Dosimeters are necessary for comfort program running;
- The program runs under OS Windows 2000/XP/VISTA, Windows 7.

2.4.7.2 For using the dosimeter in the mode of data transmission to PC it is necessary to:

- read the user software supplied on CD;
- connect the adapter of IR communication channel to a PC COM port (using the adapter built in a PC shall be permitted);
- install the unit of IrDA communication in the system and switch on the IR connection in the mode of searching external IR connection devices;
- install the user software supplied on CD to PC;
- orient the dosimeter and adapter of IR communication channel of the PC by placing the dosimeter at a distance of 10-20 cm from the adapter of IR channel;
- choose the mode of data transmission to PC using the **MODE** button (figure 2.1);
- press and release the **LIGHT/SET** button for PC link startup through IR channel;
- perform readout of the dosimeter's information, following the program's instructions.

2.4.7.3 Allow or prohibit operation modes (parameters) of dosimeter (PM1621M, PM1621MA):

- DER measurement;
- DER coefficient variations indication;
- indication of DER averaging time;
- DE measurement;

- DE accumulation time indication;
- indication of counter of the left time of presence on the work place depending in current measured DER and DE values;
- dosimeter number indication;
- audio alarm;
- setting DER and DE threshold values using buttons;
- reset DE using buttons.

2.4.7.4 Read-out from dosimeter to PC the following information (PM1621M, PM1621MA):

- dosimeter parameters;
- DER history and DE accumulation (date, time, event, value);
- DE value (DER) at the moment of set threshold exceeding, as well as time, date and month when set thresholds were exceeded;
- values of set DE and DER thresholds;
- service information.

2.4.7.5 Record from PC into dosimeter the following information (PM1621M, PM1621MA):

- dosimeter parameters;
- DE and DER threshold values;
- recording interval of DER history and DE accumulation;
- current time and date for generating DE accumulation history;
- service information.

2.4.8 Search mode (PM1621M, PM1621MA)

In the search mode the dosimeter enables functions of detection and localization of gamma radiation sources (GRS). See figure 2.2 for the way to switch search mode on.

When first DER threshold level is exceeded (GRS are detected), audio, light and vibro alarms rate will increase as the dosimeter is being moved closer to GRS.

When limiting frequency is reached, the dosimeter will emit continuous audio alarm. At single pressing of **LIGHT/SET** button the frequency of audio, light and vibro alarms can be decreased, that improves dosimeter's detection power when it gets closer to GRS.

Another pressing the **LIGHT/SET** button resets the frequency of audio, light and vibro alarms to initial state. When second DER threshold level is exceeded, dosimeter emits frequent discontinuous audio, light and vibro alarms.

When doing localization of GRS place the dosimeter so that dosimeter's effective center (attachment C, figure C.1) faces the tested object. Hold the dosimeter at the distance of the tested object no more than 10 cm. Move the dosimeter alongside the tested object no faster than 10 cm/s.

2.4.9 Indication mode of audio alarm state (PM1621M, PM1621MA)

In the indication mode of audio alarm state (figure 2.2) the dosimeter enables following functions:

- audio alarm on/off;
- indication when audio alarm is on/off;
- adjust audio alarm sound pressure (figure 2.5);
- indicate sound pressure level as analogous scale and digitally (from 1 to 4). Level 1 (one line) corresponds to minimum sound level, and level 4 (four lines) corresponds to maximum sound level.

2.4.10 Indication mode of vibro alarm state (PM1621M, PM1621MA)

In the indication mode of vibro alarm state (Figure 2.2) the dosimeter enables following functions:

- vibro alarm on/off;
- indication when vibro alarm is on/off.

2.4.11 Partial or critical battery discharge indication mode

The dosimeter controls battery discharge once in 10 minutes.

In case of the battery **partial discharge** (approximately ≤ 1.1 V) the LCD will indicate the flashing symbol "bat". **The battery is to be replaced!** (3.3) In case of the battery **critical discharge** (approximately ≤ 0.9 V) the dosimeter will turn into the DE measurement mode, the symbol "bat" will become solid, the dosimeter will stop the measurements, LCD backlight and audible alarm will become locked. **The battery is to be replaced!** (3.3)

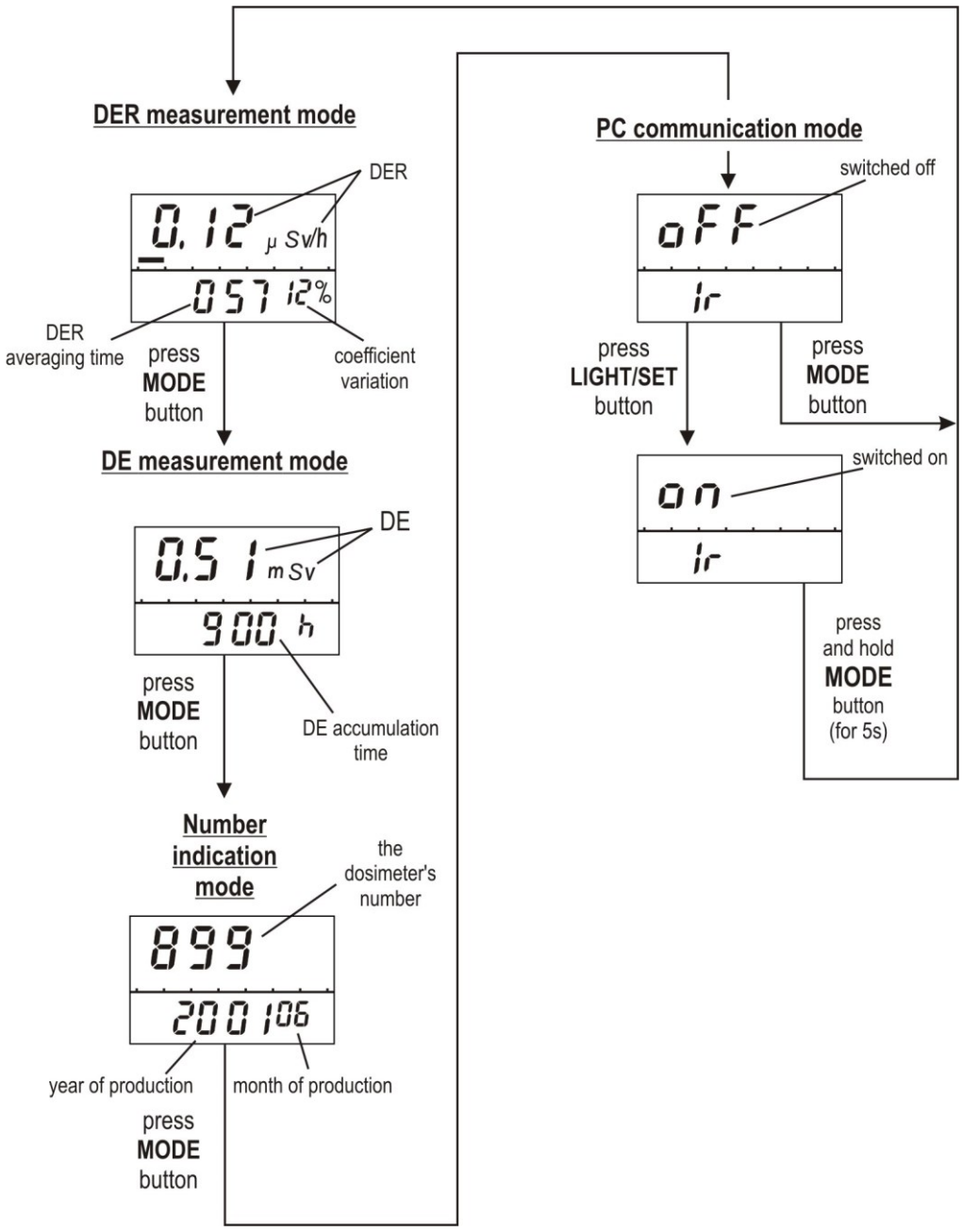

Figure 2.1 – Select the PM1621 (PM1621A) dosimeter operating (indication) mode

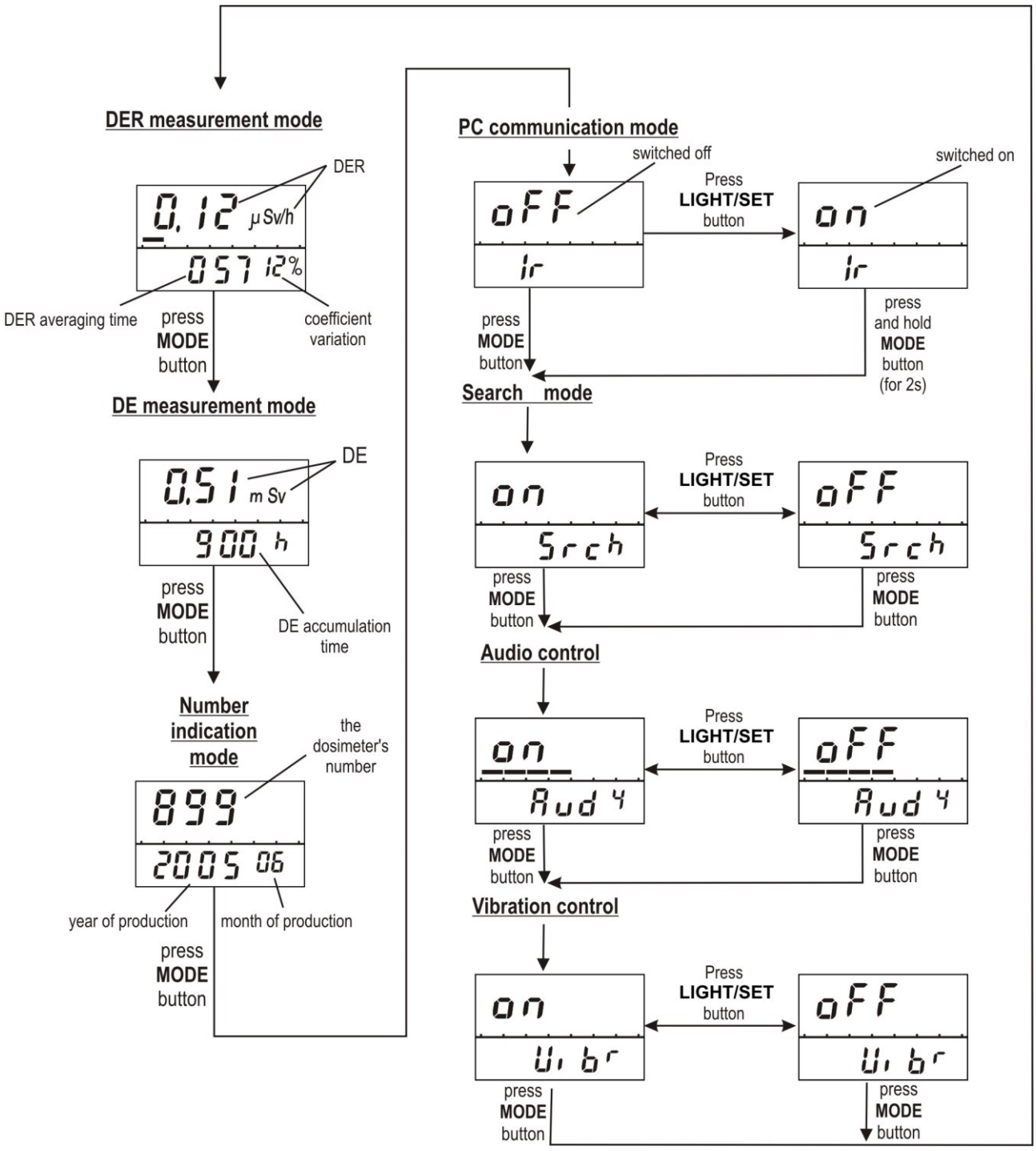

Figure 2.2 – Select the PM1621M (PM1621MA) dosimeter operating (indication) mode

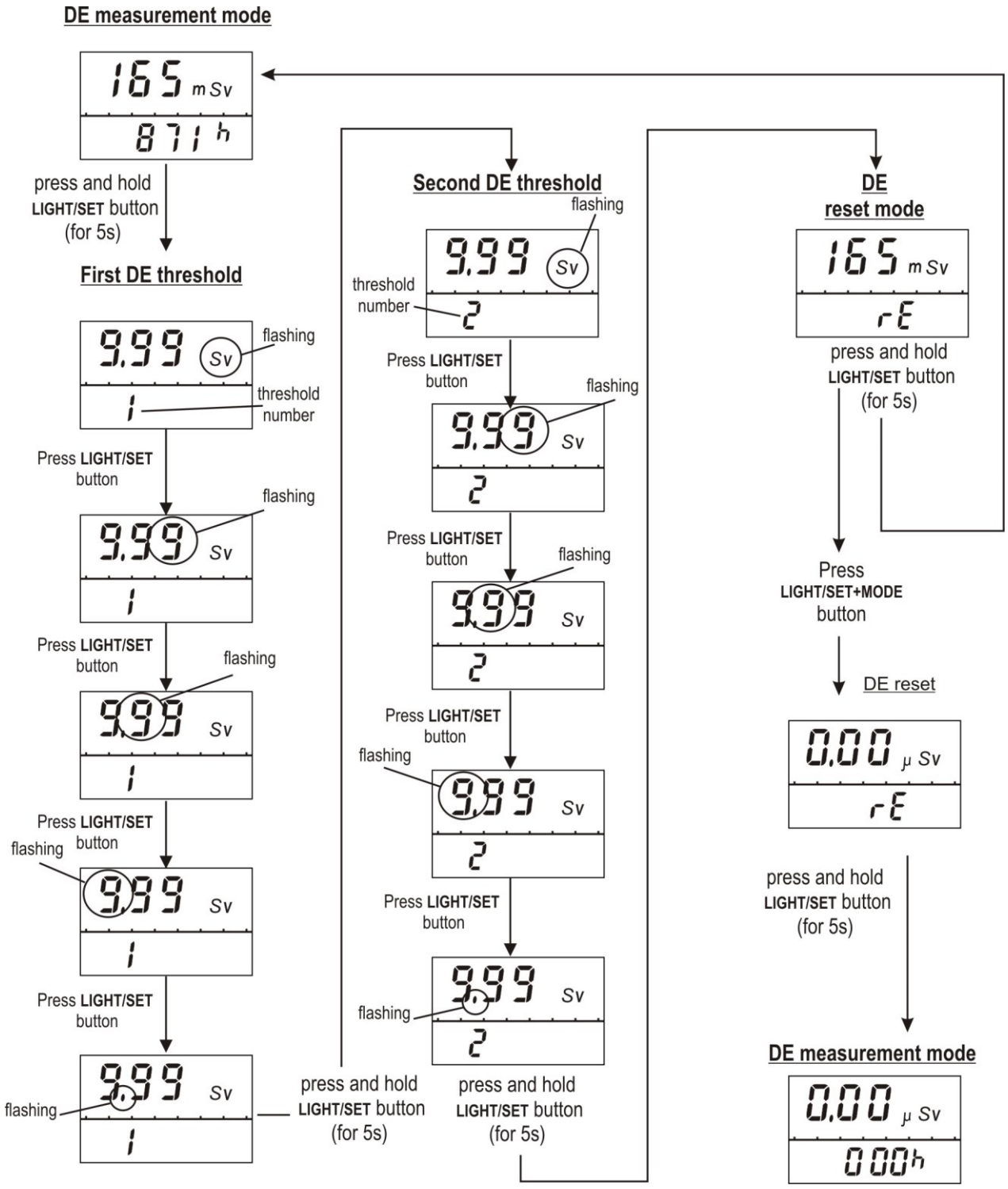

Figure 2.3 – Setting the DE threshold values

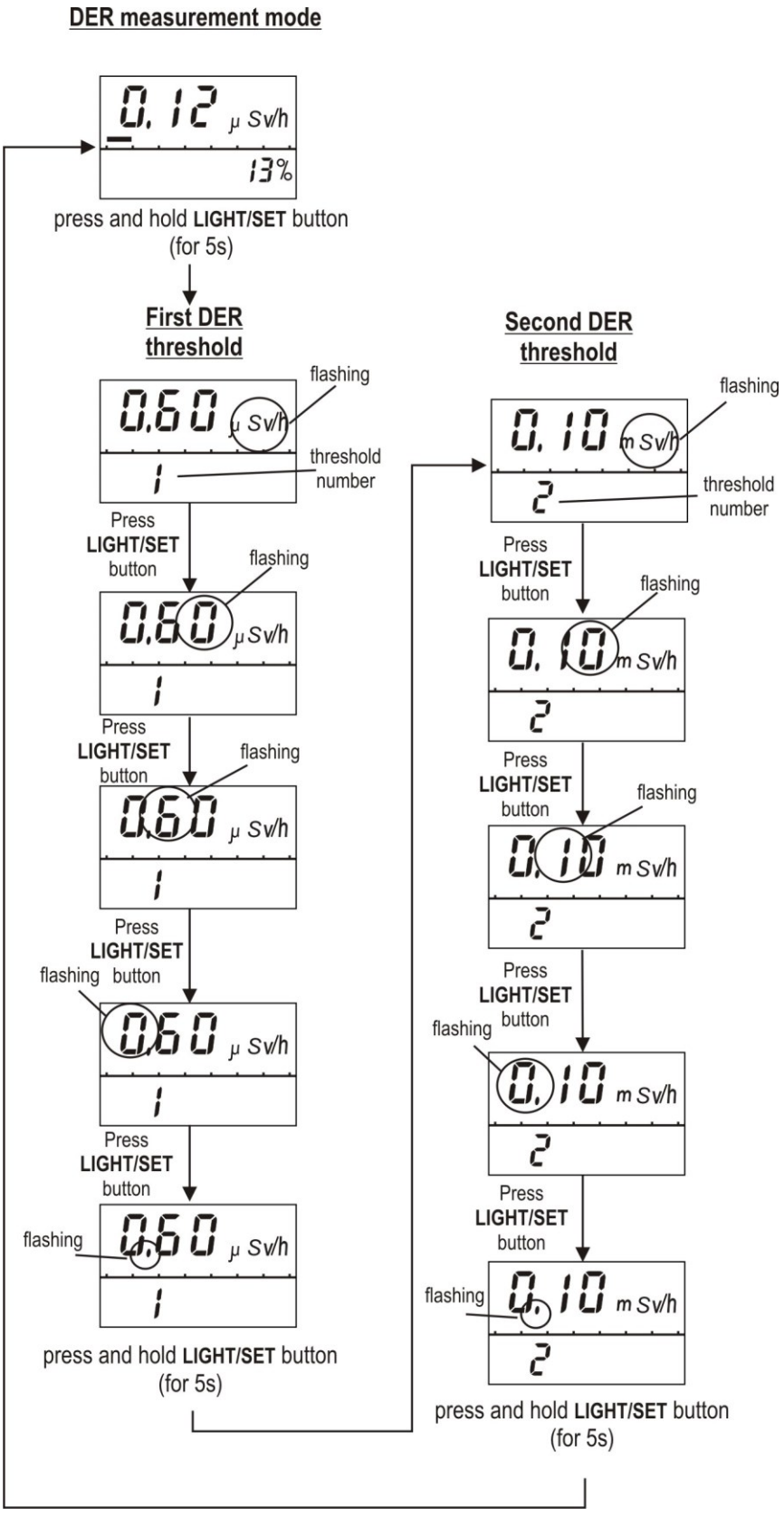

Figure 2.4 – Setting the DER threshold values

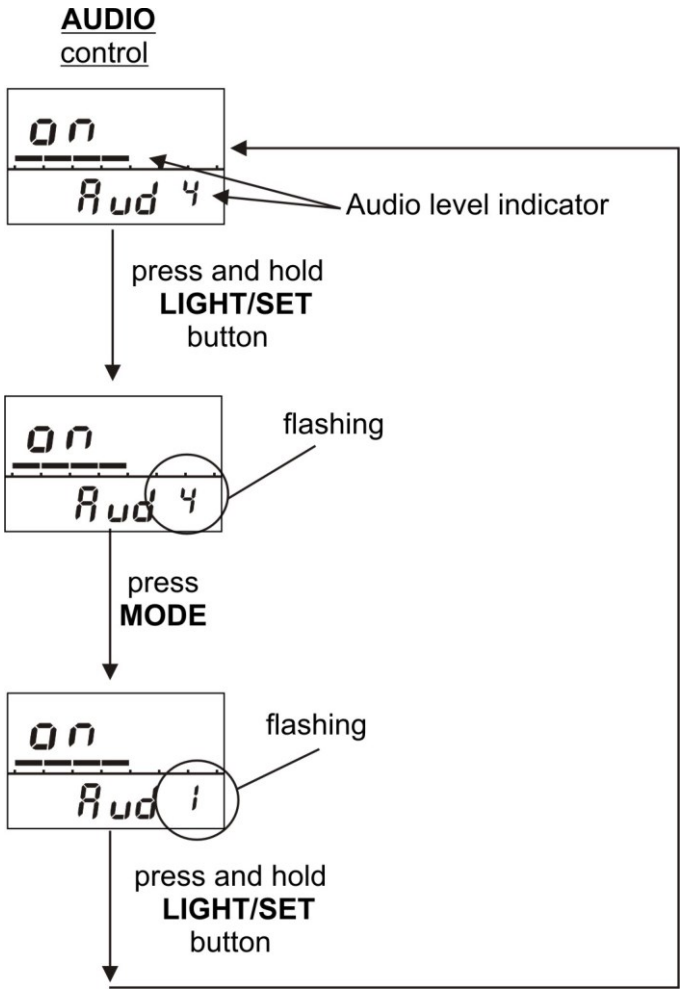

Figure 2.5 – Indication of audio alarm state
(on/off, adjustment of sound volume of PM1621M (PM1621MA) dosimeter)

3 MAINTENANCE

3.1 Maintenance involves preventive services, battery replacement and regular performance check (according to 2.4.3 - 2.4.5).

3.2 Preventive services include external examination, dusting and decontamination in the event of radioactive contamination.

For decontamination wipe the case of the dosimeter using a cloth wetted with ethanol.

3.3 Battery replacement:

- unscrew and remove the cover of the battery compartment;
- remove the old battery;
- insert the new battery observing the polarity (the “+” sign of the battery should be inwardly directed);
- fix the cover of the battery compartment in its place.

After the battery is replaced, the LCD will display all segments, and then the dosimeter should enter the measurement mode. All the previous measurements and parameters necessary for proper operation of the dosimeter are stored in its non-volatile memory.

NOTE – Insert a new battery before sending a dosimeter for calibration.

4 TROUBLESHOOTING

The list of possible problems and their solutions are specified in the table 4.1.

Table 4.1

Problem	Possible cause	Solution
1 The LCD indicates “bAt” message	Battery discharge	Replace the battery
2 No indications on the LCD	Battery discharge Battery is inserted incorrectly	Replace the battery Insert the battery in the proper way
3 The Dosimeter does not respond to pressing a button, the LCD indicates incorrect symbols	Microprocessor error condition	Remove the battery and insert it again in 5 min
4 The LCD indicates Er1-Er7	Dosimeter failure	Send the Dosimeter for repair to the manufacturer’s maintenance center
Note – If a defective battery is used the Er1 – Er7 message may appear. **A t t e n t i o n ! When the Er1 – Er7 message appears, press any button. When the error message appears for the second time (approximately in 15 minutes) the dosimeter is considered not suitable for operation.**		

5 VERIFICATION METHOD

5.1 Introduction

Current verification procedure covers PM1621, PM1621A, PM1621M and PM1621MA (further – dosimeters) and scheduled dosimeters verification.

Verification is done by local state metrological services (Gosstandart (state standard of manufacturer country) and correspondingly authorized companies.

Verification is done by the manufacturer on the site, after repair, while in service and storage with 12 months periodicity.

5.2 Verification procedures and tools

Verification requires the following procedures and tools, stated in the Table 5.1.

Table 5.1

Procedure name	Verification procedure chapter number	Name of reference and auxiliary measurement tools; their main characteristics
External examination	5.7.1	-
Testing	5.7.2	-
Metrological examination	5.7.3.1, 5.7.3.2	Calibration assembly with ^{137}Cs source. Certified uncertainty of calibration assembly must be no more than 5 % at confidence probability 0.95
-	5.5	Barometer. Scale interval 1 kPa. Measurement range 60 - 120 kPa
-	5.5	Thermometer. Scale interval 0.1°C. Measurement range 10 - 30°C
-	5.5	Hydrometer. Measuring range 30 - 90%
-	5.5	Stopwatch. Range of measurement from 1 to 600 s
-	5.5	Dosimeter DBG-06T. Main error ± 15%. (Another dosimeter allowing required measurement accuracy can be used)
-	5.7.3	Water phantom, dimensions 30x30x15 cm*
* A plane-parallel phantom from PMMA, dimensions 30x30x15 cm, can be used		

5.3 Verification officers' qualification requirements

Only persons certified as state verification officers in accordance with established procedure are allowed to conduct measurements during verification and (or) analyze measurement results.

5.4 Safety requirements

5.4.1 Obligatory safety requirements for verification:

- any works with radioactive sources must be done according to state and local safety instructions for radioactive sources and other ionizing radiation sources valid at the verification site.

5.4.2 Verification process must be referred to working under harmful labor conditions.

5.5 Verification conditions

Verification requires following conditions:

ambient air temperature……..(20 ± 5) °C
relative air humidity……60 (+20;- 30) %
atmospheric pressure……101.3 (+5.4; -15.3) kPa
ambient gamma radiation……..no more than 0.2 μSv/h

5.6 Pre-verification procedure

Pre-verification requires following preparatory procedures:
- carefully read current Operation Manual;
- make instrument ready for operation according Chapter 2.3 of the current Operation Manual.

5.7 Verification procedure

5.7.1 External examination of the instrument

When doing external examination, be sure that the instrument corresponds to the following requirements:
- instrument delivery kit corresponds to Operation Manual requirements;
- there is initial verification mark in the Operational Manual or certificate of the last verification;
- there are clear markings on the instrument's surface;
- there is no dirt and mechanical damages that can influence instrument operation.

Instrument is considered as not valid for further verification if it doesn't meet the above requirements.

5.7.2 Carrying out verification (testing)

Testing requires following:
- check instrument operability according to Chapter 2.4 of current Operation Manual;
- set maximum threshold levels of personal dose equivalent rate $\dot{H}_p(10)$ (further – DER) and personal dose equivalent $H_p(10)$ (further – DE) according to Chapter 2.4.5 of current Operation Manual.

5.7.3 Metrological examination

5.7.3.1 DER measurement main relative error is calculated as follows:
1) switch on DER measurement mode;
2) fasten the dosimeter on the phantom so that "This side to body" inscription faces the phantom. Place the dosimeter with phantom onto the verification dosimetric unit so that the normal line from the geometrical center of phantom's front wall coincides with the central axis of collimator of verification dosimetric unit. Central axis of collimator of verification dosimetric unit must go through geometrical center of detector of the dosimeter being tested, figure 5.1. Geometrical center of detector is stated in the dosimeter's Operation Manual;

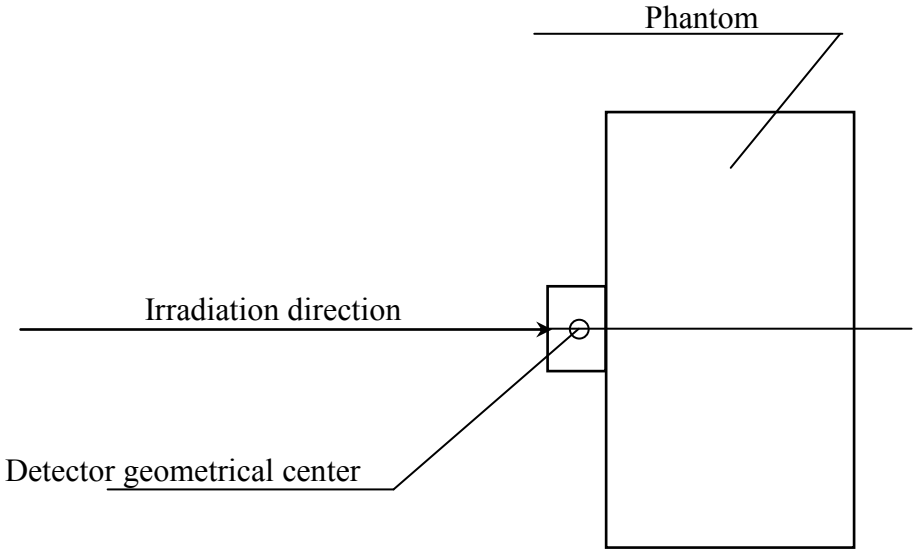

Figure 5.1 – The way for dosimeter with phantom be placed on the verification dosimetric unit

3) calculate an average value of measured gamma radiation ambient background DER (further – gamma background) when there is no reference radiation source. To do it, wait no less than 600 s from the moment the instrument was placed on the dosimetric equipment and then take 5 DER measurement readings at 150 s interval (no less). Then calculate average DER meaning of gamma background $\overline{\dot{H}_b}$, by formula (5.1). One segment of analogue scale must be indicated.

$$\overline{\dot{H}_b} = \frac{1}{5}\sum_{i=1}^{5}\dot{H}_{bi}, \qquad (5.1)$$

where $\dot{H}_{bi}$ – i-th meaning of gamma background DER measurement, μSv/h;

4) move the dosimeter on the dosimetric unit so that geometrical center of the detector coincides with the reference point, where reference DER value is 3,0 μSv/h, and expose the dosimeter to irradiation. At that two segments of analogue scale must be indicated;

5) wait at least 100 s after exposure starts, then take 5 DER measurement readings (at 60 s interval at least). Then calculate average DER value $\overline{\dot{H}_j}$ by formula

$$\overline{\dot{H}_j} = \frac{1}{5}\sum_{i=1}^{5}\dot{H}_{ji}, \qquad (5.2)$$

where $\dot{H}_{ji}$ – i-th dosimeter reading when measuring DER in j-th tested point;

6) repeat measurements for points where reference DER value is 80,0; 800 μSv/h. At that three segments of analogue scale must be indicated if DER is 80,0 μSv/h and four segments if DER is 800 μSv/h;

7) move the dosimeter on the dosimetric unit so that geometrical center of the detector coincides with the reference point, where reference DER value is 8,0 mSv/h;

8) expose the dosimeter to irradiation, at that five segments of analogue scale must be indicated;

9) wait at least 60 s after exposure start, then take 5 DER measurement readings (at 20 s interval at least) and then calculate average DER value by $\overline{\dot{H}_j}$ by formula (5.2);

10) repeat the measurement for the reference point where reference DER value is 80 mSv/h. At that six segments of analogue scale must be indicated;

11) when using PM1621A, PM1621MA dosimeters: repeat measurements according to article 9) for the reference point where reference DER value is 800,0 mSv/h. At that seven segments of analogue scale must be indicated;

12) calculate relative measurement error Q_j, %, by formula

$$Q = \frac{\left(\overline{\dot{H}_j} - \overline{\dot{H}_b}\right) - \dot{H}_{oj}}{\dot{H}_{oj}} \times 100, \qquad (5.3)$$

where $\dot{H}_{oj}$ – reference DER value in the tested point;

$\overline{\dot{H}_j}$ – average DER value in the tested point;

$\overline{\dot{H}_b}$ – average DER value of gamma background in μSv/h equal to 3,0; 80,0 and 800,0 μSv/h and average DER value of gamma background in mSv/h when reference DER is 8,0; 80,0 и 800,0 mSv/h;

13) calculate the error confidence limit of the dosimeter δ, %, with the confidence probability 0,95 under test by formula

$$\delta = 1.1\sqrt{(Q_o)^2 + (Q_{jmax})^2}, \qquad (5.4)$$

where Q_o – uncertainty of the reference dosimeter assembly, %;

Q_{jmax} – maximum measurement error of all Qj values, %;

14) compare the calculated value δ with an acceptable value δ_{add} calculated by formula

$$\delta_{add} = \pm(15 + 0{,}0015/\dot{H} + 0{,}01\cdot\dot{H})\ \%, \qquad (5.5)$$

where $\dot{H}$ – DER value, mSv/h;

0,0015 – coefficient, mSv/h;

0,01 – coefficient, $(mSv/h)^{-1}$.

The dosimeter passes the test if $\delta < \delta_{acc}$.

5.7.3.2 DE measurement main relative measurement error is calculated as follows:

1) set maximum DER and DE threshold levels on the dosimeter and switch on DE measurement mode;

2) do actions described in 5.7.3.1.(2);

3) read initial DE value from the dosimeter;

4) move the dosimeter on the dosimetric unit so that geometrical center of the detector coincides with the reference point, where reference DER value from the reference gamma source ^{137}Cs is 3,0 μSv/h, and irradiate the dosimeters during T time equal to 60 min;

5) read end DE value from the dosimeter when irradiation is over;

6) calculate main relative DE measurement error Q_j, in percents, by formula

$$Q_j = \frac{(H_{kj} - H_{Hj}) - \dot{H}_{oj}\cdot T}{\dot{H}_{oj}\cdot T} \times 100, \qquad (5.6)$$

where $H_{кj}$ – end DE value, mSv;

$H_{нj}$ – initial DE value, mSv;

$\dot{H}_{oj}$ – reference DER value in the tested point, mSv/h;

T – irradiation time in hours.

7) repeat measurements (1-6) for the reference point, at DER value equal to 80,0 mSv/h during T time equal to 30 min;

8) verification results are considered positive, if DE measurement error results for all tested points, Q_j, don't exceed $\delta_{add} = \pm$ 15 %.

6 STORAGE AND SHIPPING

6.1 Dosimeters in package may be shipped by any kinds of closed transport at the air temperature from -50 to +50 °C.

6.2 Dosimeters in package should be arranged and fastened in the transport so that their stable position is ensured and shocks are avoided.

6.3 When carried by sea, Dosimeters in package should be placed in hermetic plastic bags with silica gel.

6.4 When carried by air, Dosimeters in package should be placed in hermetic compartments.

6.5 Dosimeters should be stored in the manufacturer's package at the air temperature from -15 to +50 °C and air relative humidity up to 95 % at a temperature of 35°C.

6.6 Dosimeters without package are to be stored at the air temperature from 10 to 35 °C and relative humidity up to 80 % at a temperature of 25 °C.

6.7 The storage place should be free of dust, vapors of strong chemicals, aggressive gases and other substances that may cause corrosion.

7 WARRANTY

7.1 The manufacturer warrants this instrument to meet specifications provided that the user follows the instructions for the operation of the instrument, shipping and storage described in the Operation manual.

7.2 Warranty operation period is 18 months since the date the instrument putting into operation. If there is no mark on instrument putting into operation, then the warranty period will be started from the date of warranty shelf-life end.

7.3 The warranty period is 6 months since the date of manufacturer Quality Control Department accepting the instrument.

7.4 Warranty and after-warranty repairs are performed by the manufacturer or by a company authorized by the manufacturer.

7.5 Warranty does not cover the instruments:

- subjected to the user's service (the instrument was tampered/opened by the user);
- with mechanical damages, if the requirements of operation and storage were not satisfied;
- without the operation manual;
- if their warranty period is expired.

7.6 The warranty period is extended for a period of warranty repair.

7.7 Warranty doesn't cover the batteries. The battery replacement is not considered as the warranty repair.

ATTACHMENT A
(reference)

Typical instrument anisotropy
(data are normalized to the calibration direction 0°)

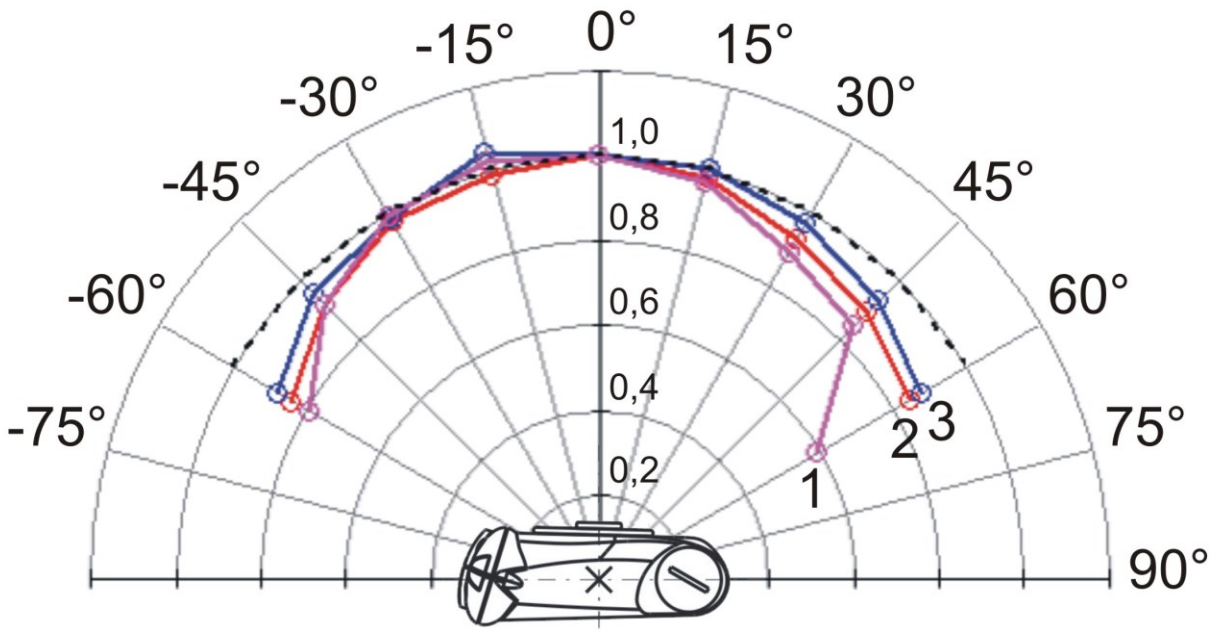

Figure A.1 – for horizontal installation at the phantom (rotation in vertical plane):
1 – ^{241}Am (59,5 keV); **2** – ^{137}Cs (662 keV); **3** – ^{60}Co (1250 keV)

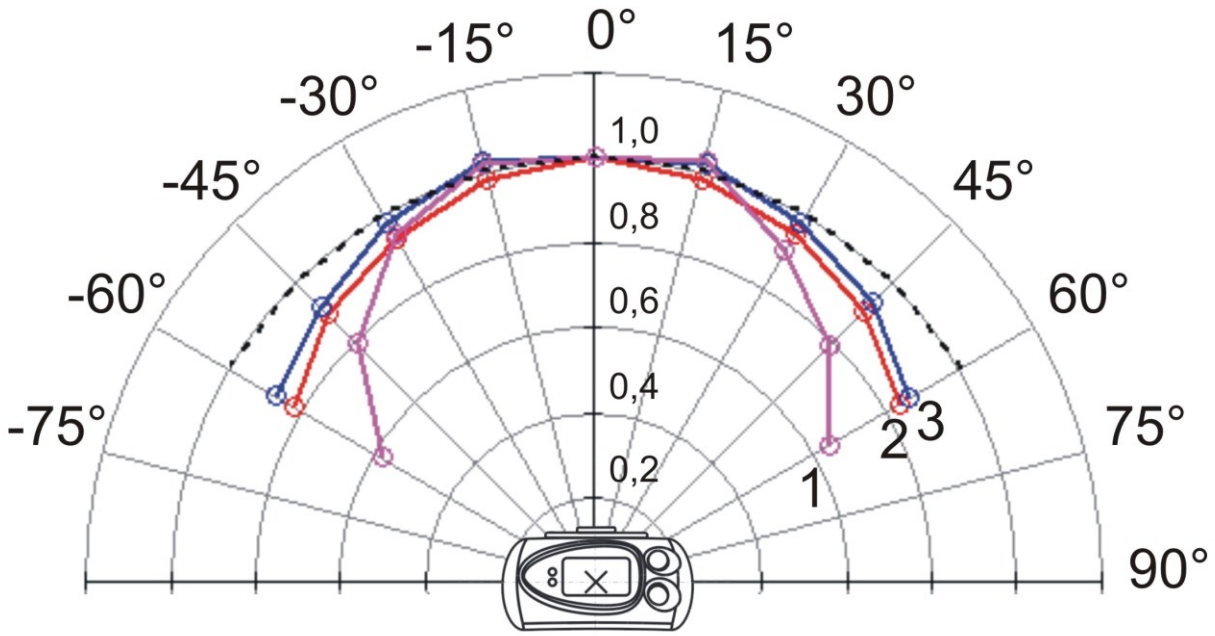

Figure A.2 – for vertical installation at the phantom (rotation in horizontal plane):
1 – ^{241}Am (59,5 keV); **2** – ^{137}Cs (662 keV); **3** – ^{60}Co (1250 keV)

ATTACHMENT B

(reference)

Diagram of dosimeter rotation to measure angular response

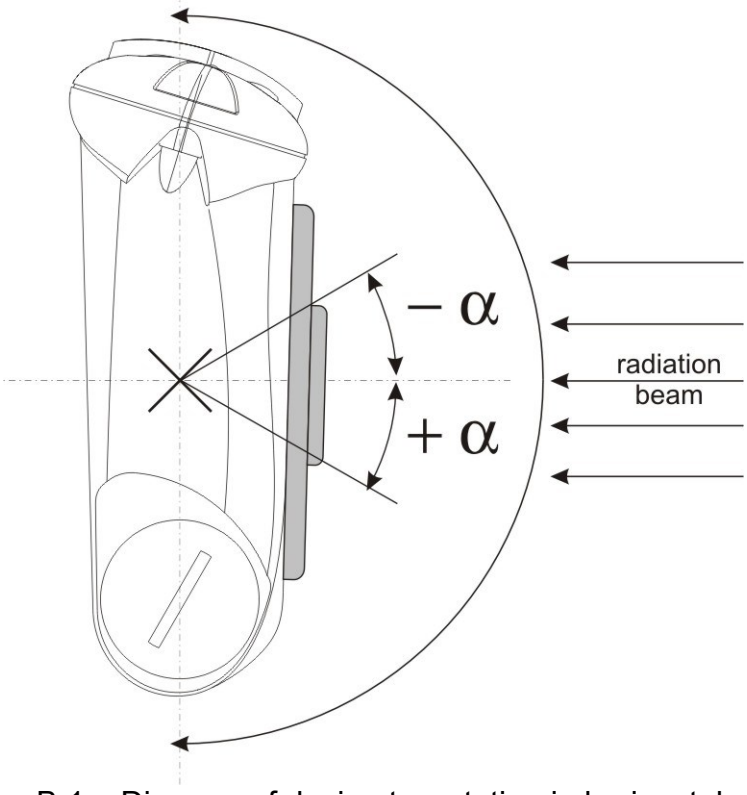

Figure B.1 – Diagram of dosimeter rotation in horizontal plane

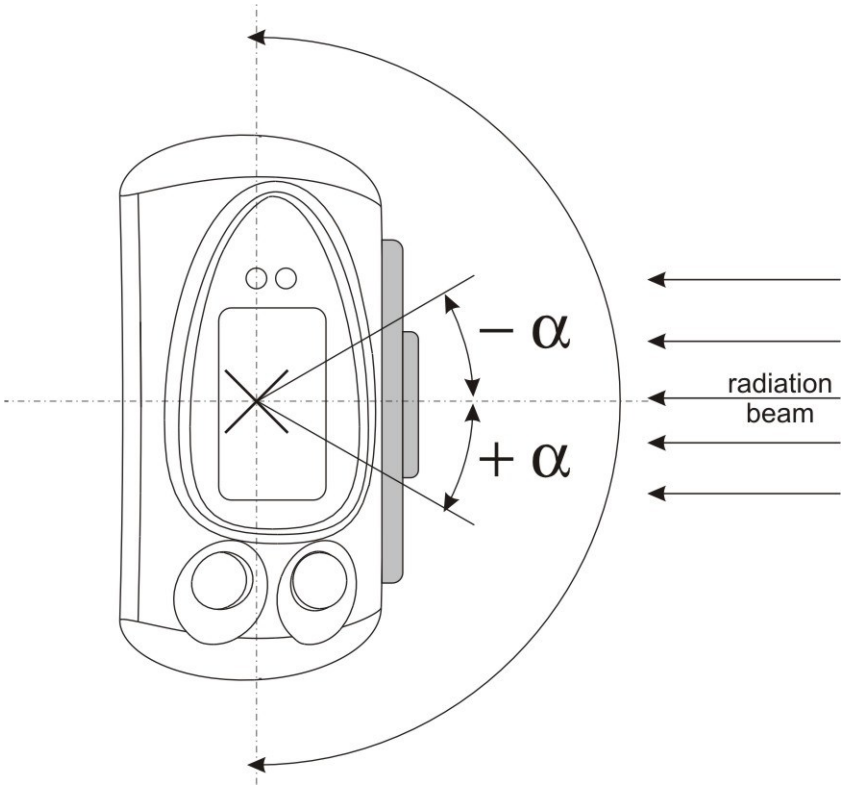

Figure B.2 – Diagram of dosimeter rotation in vertical plane

ATTACHMENT C
(reference)

Overall dimensions, effective center of the dosimeter detector

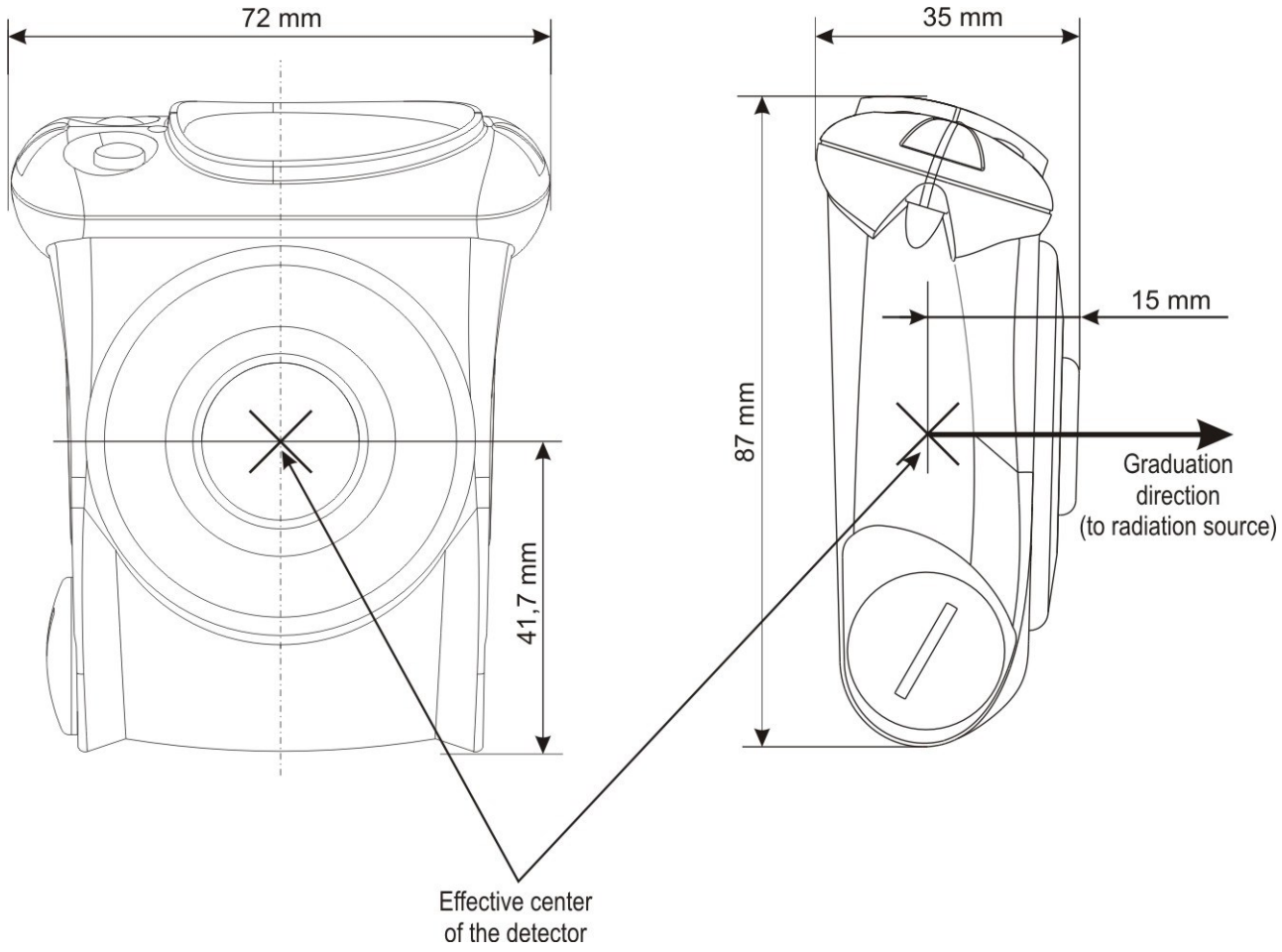

Figure C.1